Geological Survey
of Canada

CURRENT RESEARCH
2001-A4

Late Cenozoic geology, Ancient Pacific Margin Natmap Project, report 4: paleomagnetic and geomorphic evidence for Brunhes-age volcanism, Fort Selkirk and Rosebud Creek area, Yukon Territory

Crystal A. Huscroft, Rene W. Barendregt, and Lionel E. Jackson, Jr.

2001

Natural Resources Canada Ressources naturelles Canada

Canada

©Her Majesty the Queen in Right of Canada, 2001
Catalogue No. M44-2001/A4E
ISBN 0-660-18384-6

Available in Canada from the
Geological Survey of Canada Bookstore website at:
http://www.nrcan.gc.ca/gsc/bookstore (Toll-free: 1-888-252-4301)

A copy of this publication is also available for reference by depository libraries across Canada through access to the Depository Services Program's website http://dsp-psd.pwgsc.gc.ca. A list of these libraries can be consulted at this site or obtained by calling the toll-free number above.

Price subject to change without notice

All requests for permission to reproduce this work, in whole or in part, for purposes of commercial use, resale or redistribution shall be addressed to: Earth Sciences Sector Information Division, Room 200, 601 Booth Street, Ottawa, Ontario K1A 0E8.

Authors' addresses

C.A. Huscroft *(chuscroft@nrcan.gc.ca)*
Department of Earth Sciences
Simon Fraser University
Burnaby, B.C. V5A 1S6

R.W. Barendregt
Department of Geography
University of Lethbridge
Lethbridge, Alberta T1K 3M4

L.E. Jackson, Jr. *(ljackson@NRCan.gc.ca)*
Terrain Sciences Division
Geological Survey of Canada
101-605 Robson Street
Vancouver, B.C. V6B 5J3

Late Cenozoic geology, Ancient Pacific Margin Natmap Project, report 4: paleomagnetic and geomorphic evidence for Brunhes-age volcanism, Fort Selkirk and Rosebud Creek area, Yukon Territory[1]

Crystal A. Huscroft, Rene W. Barendregt, and Lionel E. Jackson, Jr.
Terrain Sciences Division, Ottawa

Huscroft, C.A., Barendregt, R.W., and Jackson, Jr., L.E., 2001: Late Cenozoic geology, Ancient Pacific Margin Natmap Project, report 4: paleomagnetic and geomorphic evidence for Brunhes-age volcanism, Fort Selkirk and Rosebud Creek area, Yukon Territory; Geological Survey of Canada, Current Research 2001-A4, 6 p.

Abstract: Normally magnetized, valley-filling basalt flows extend more than 10 km down the Yukon River valley from the Fort Selkirk area. These flows are locally overlain by gravel and terminate at the level of the contemporary Yukon River flood plain, suggesting a middle to late Pleistocene age for this previously unrecognized eruptive event. Unlike other valley-filling phases of the Selkirk Volcanic Group, this eruption postdates the Pliocene to early Pleistocene pre-Reid glaciations. Normal magnetism was also determined for basalt flows underlying terraces in the area of the Rosebud Creek–Grand Valley Creek confluence, 60 km to the northwest of the Fort Selkirk area. Based on their unique geomorphic and stratigraphic settings, the Rosebud basalt flows may represent yet another period of Pleistocene volcanism which predates one of the pre-Reid glaciations in the central Yukon Territory.

Résumé : Les coulées de basalte à aimantation normale qui remplissent les vallées s'étendent sur plus de 10 km vers l'aval du fleuve Yukon à partir de la région de Fort Selkirk. Ces coulées sont recouvertes de graviers par endroits et se terminent près de la plaine d'inondation actuelle du fleuve Yukon, ce qui permet de supposer que cette éruption auparavant non reconnue remonte au Pléistocène moyen à supérieur. Contrairement à d'autres phases remplissant les vallées du groupe volcanique de Selkirk, cette éruption est survenue après les glaciations du Pliocène–Pléistocène inférieur antérieures à la Glaciation de Reid. On a également observé que l'aimantation des coulées de basalte sous-jacentes aux terrasses était normale dans la région de confluence des cours d'eau Rosebud et Grand Valley, à 60 km au nord-ouest de la région de Fort Selkirk. D'après leurs contextes géomorphologiques et stratigraphiques uniques, les coulées de basalte de Rosebud représenteraient une autre période de volcanisme pléistocène qui date d'avant l'une des glaciations antérieures à la Glaciation de Reid dans le centre du Territoire du Yukon

[1] Contribution to the Ancient Pacific Margin NATMAP Project.

INTRODUCTION

This paper reports the results of paleomagnetic sampling of lava flows along the Yukon and Stewart rivers in the Carmacks and Stewart River map areas (115-I and 115 N) during the summer field season of 2000 as a part of the Geological Survey of Canada's Ancient Pacific Margin NATMAP (National Geoscience Mapping Program) Project (Fig. 1). The objective of this work was to refine the stratigraphy established for Pleistocene sediments and interstratified basalts found in terraces in the Carmacks map area (Jackson et al., 1996) and extend it down the Yukon River valley into the Stewart River map area. The ultimate goal of this study is to constrain the age of Stewart River and Yukon River terraces.

The age of Yukon and Stewart River terraces is significant in establishing the geomorphic context of placer deposits found in the study area. River terraces record periods of aggradation, stability, and incision. These changes in local base level have the capability of preserving, enriching, or destroying placer gold deposits in tributary drainages. Hence, an understanding of the fluvial history of an area is an essential tool in identifying geomorphic targets for exploration. Commonly, lack of datable material associated with the terraces within the Stewart River map area precludes the determination of their age. However, near Fort Selkirk and Rosebud Creek (Fig. 2), basaltic flow complexes of the Selkirk Volcanic Group (Bostock, 1936) are interstratified with glacial and nonglacial sediments. This stratigraphy provides a valuable opportunity to compile age control for aggradation of the Yukon and Stewart rivers.

REGIONAL SETTING

The study area is set between the glaciated and unglaciated environments of the Yukon Plateau, central Yukon Territory. The lava flows associated with the Selkirk Volcanic Group lie 60 km beyond the limit of the Late Wisconsinan age McConnell Glaciation, straddle the limit of the penultimate (Reid) glaciation (thought to have occurred 200–400 ka BP), but are within the limit of pre-Reid glaciations (Bostock, 1966; Jackson et al., 1996; Duk-Rodkin, 1999) that predate the last magnetic reversal ca. 0.8 Ma. The region is bounded to the south by the Dawson Range, and to the north by the Klondike valley and Ogilvie Mountains. The Yukon Plateau is a gently sloping upland consisting of concordant summits, locally termed "domes", connected by long ridges separated by deeply incised V-shaped valleys. The plateau is considered to be an uplifted erosional surface produced as a result of extensive subaerial exposure during the early-mid-Tertiary (Hughes et al., 1969). Flights of terraces are located along the

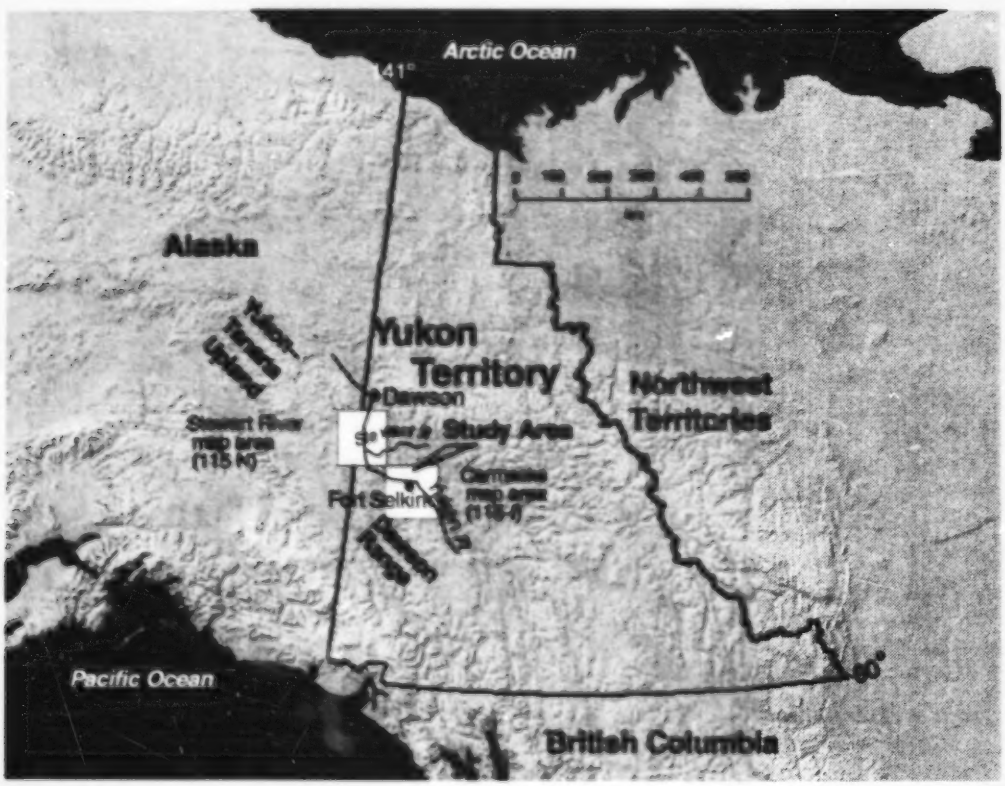

Figure 1. *Location of Carmacks and Stewart River map areas plotted on a digital shaded relief map.*

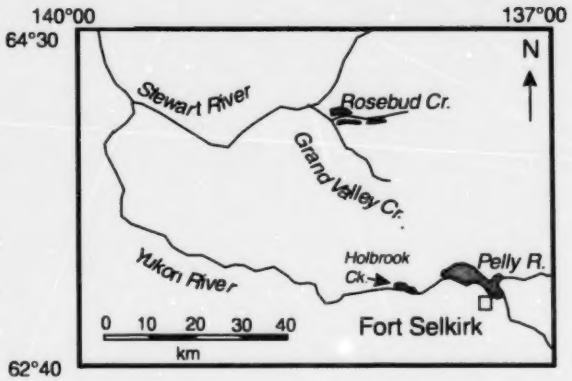

Figure 2. *Location of Rosebud Creek and Holbrook Creek lava flows with reference to Fort Selkirk. Shaded areas depicts distribution of lava flows.*

Yukon and Stewart rivers, as well as major tributary valleys. Only in the vicinity of Fort Selkirk and Rosebud Creek do they contain basaltic lava flows.

PREVIOUS WORK

Previous chronostratigraphic studies of terraces in the Fort Selkirk area have included paleomagnetic investigations and radiometric dating of both ash and selected basalt flows of the Selkirk Volcanic Group. Dubois (1959) first discovered that both magnetically normal and reversed polarities are present within the Selkirk Volcanic Group. Wood from a diamicton lying under the lava flows opposite Fort Selkirk yielded and age greater than 38 ka BP (Walton et al., 1961). Subsequent work by Bostock (1966) inferred that the terrace deposits exposed at Fort Selkirk contain evidence of two glaciations. Naeser et al. (1982) and Westgate (1989) provided the first correlation of paleomagnetic stratigraphy with the absolute time scale via fission-track age measurements of the Fort Selkirk tephra and K-Ar measurements of selected flows. Francis and Ludden (1990) characterized the their chemical stratigraphy of the valley-filling basalt flows along both the Yukon and Pelly rivers and grouped them as the "Pelly Sequence". Extensive magnetostratigraphic studies of both volcanic flows and interstratified glacial and nonglacial sediment associated with the Selkirk Volcanic Group were performed by Jackson et al. (1990, 1996). The stratigraphy established for the Fort Selkirk area by Jackson et al. (1996) is summarized in Figure 3. Three eruptive periods related to the emplacement of flows in the Yukon River valley were identified. The first event initiated prior to the earliest pre-Reid glaciation identified in the central Yukon is magnetically reversed and Ar-Ar dated at 1.83 ± 0.3 Ma. (M. Villeneuve, pers. comm., 2000). The intermediate flows were at least partly erupted during the youngest of the pre-Reid glaciations identified in the area and are also magnetically reversed. They overlie magnetically normal sediments (Jaramillo or Cobb Mountain subchrons) and the ca. 1.4 Ma Fort Selkirk tephra. The youngest flows in the region date from the early Holocene or latest Pleistocene and are associated with a relatively uneroded cinder cone (Volcano Mountain).

PALEOMAGNETIC STRATIGRAPHY

Several oriented cores were obtained from each sampling site using a small gasoline-powered drill. Between one and three cylindrical specimens were then cut from each core. Inclination and declination of natural remnant magnetization (NRM) were made by Dr. Neil Opdyke of the Department of Geological Sciences, University of Florida.

Fort Selkirk, Yukon River Valley

The surface of a nearly continuous package of basalt flows exposed along the Yukon River gradually decreases in relief above the Yukon River from nearly 90 m at the confluence of the Yukon and Pelly rivers, to less than 10 m at its downstream termination (tip section; Fig. 4). Jackson et al. (1996) inferred a reversed magnetic polarity for all of these flows based on samples collected from four locations across the

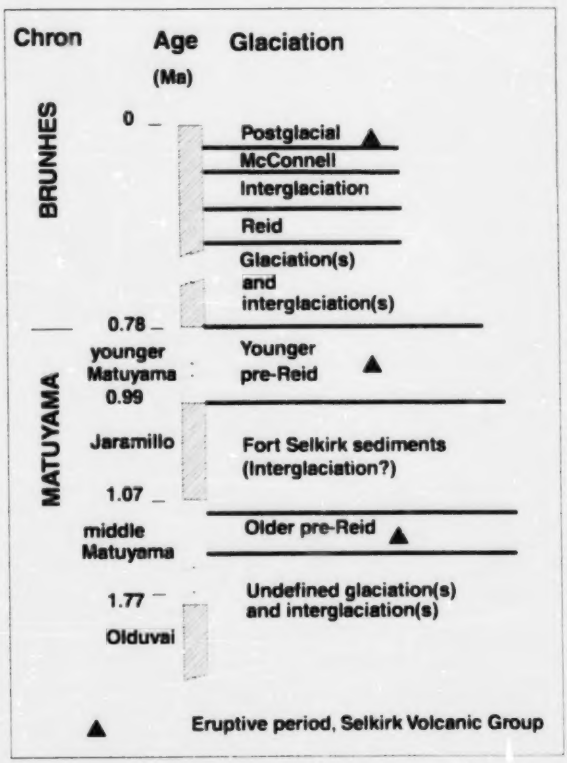

Figure 3. *Summary of stratigraphy established for the Carmacks map area by Jackson et al. (1996) correlated to the geopolarity time scale (Cande and Kent, 1995). Shaded intervals indicate periods of normal magnetism, unshaded areas indicate reversed magnetic periods.*

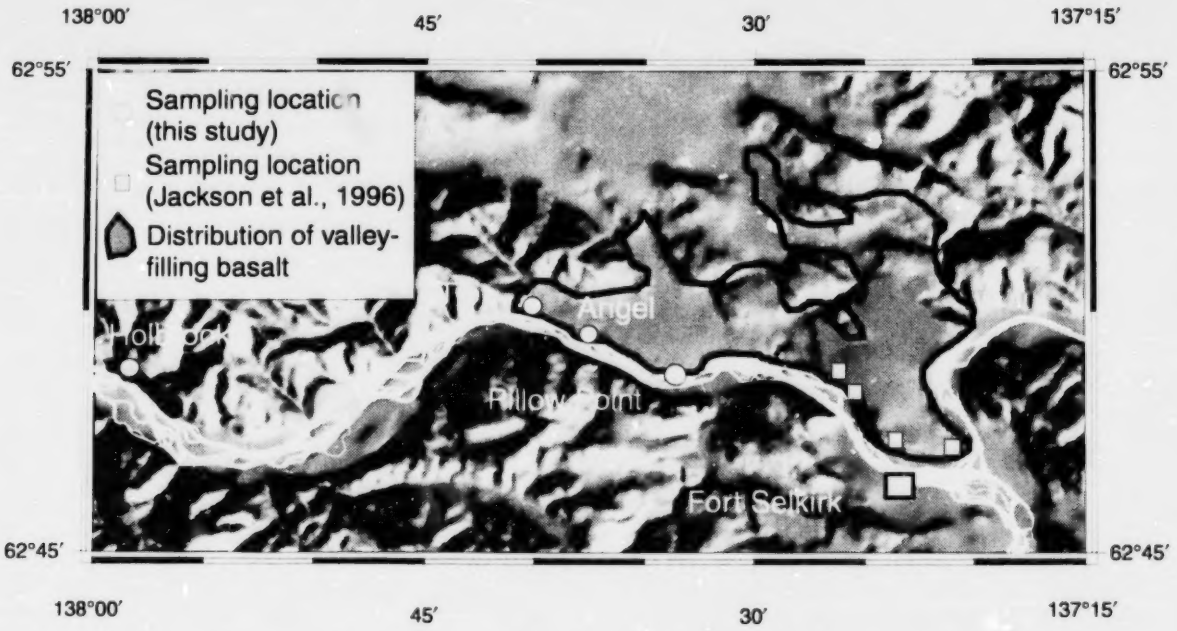

Figure 4. *Location of sample sites along Yukon River.*

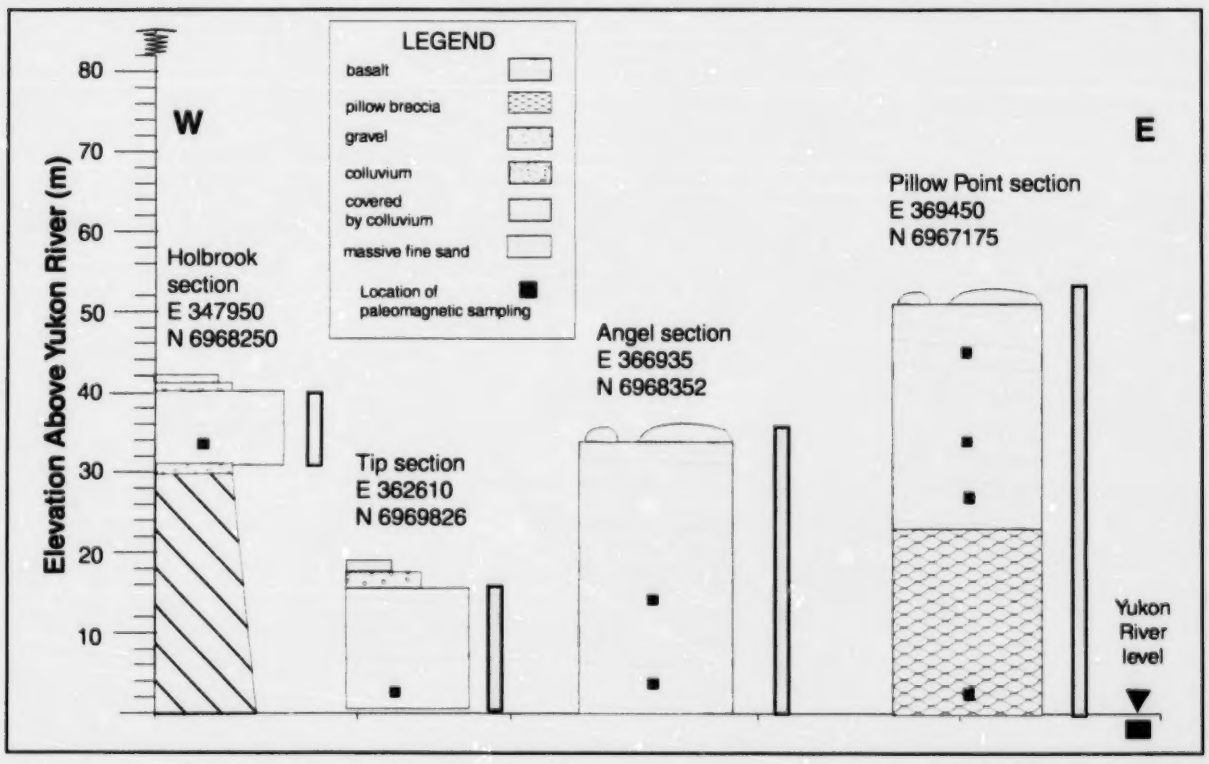

Figure 5. *Summary of sedimentary and volcanic facies and sample sites for measured and described sections. The strip log on the right of each section represents polarity: shaded areas indicate normal magnetization and unshaded areas represent reverse magnetization.*

Yukon River from the abandoned settlement of Fort Selkirk (Fig. 5). However, new investigations during the past field season have shown this interpretation to be incorrect. Less than 4 km downstream from these sites, 25 m thick foreset-bedded pillow-and-breccia complexes are found at the current level of the Yukon River floodplain (Pillow Point; Fig. 5). A flow complex capping the pillow breccia unit descends to river level within another 3 km downstream (Angel section; Fig. 5). Both pillow breccia and flow complexes at Tip, Angel, and Pillow Point proved to be normally magnetized (Fig. 4).

Holbrook Creek, Yukon River Valley

At the mouth of Holbrook Creek, 17 km downstream from the termination of the normally magnetized flows, a remnant of a single valley-filling basalt flow is traceable along the Yukon River for approximately a kilometre (Fig. 5). The surface of the flow dips up the Yukon River valley, and the thickness of the flow gradually thins from 20 m to 8 m. Lying at 30 m above the modern level of the Yukon River, the base of the flow contains pillows and overlies imbricated cobble gravel. The source of the flow is not known. It does not extend up adjacent valleys.

Rosebud Creek

Remnants of a grey, vesicular, olivine basalt lava flow occur along both sides of Rosebud Creek in the area of the confluence of Rosebud and Grand Valley creeks (Fig. 2, 6). Bostock (1942) found this flow to be up to 30 m thick and its base to locally descend to within 12 m of the contemporary floor of Rosebud Creek valley. However, the flow is usually heavily overgrown and buried by gravel and colluvium. Consequently, only the upper part of the flow is typically exposed. The eruptive source of this flow is unknown. Figure 6 is a diagrammatic representation of one of the best exposures of the flow (UTM 7V, E 638456, N 7016273). Gravel overlying the flow is well sorted and contains chert pebbles. A soil developed in the gravel and loess displays a 7.5YR 4/6 Munsell colour and thick clay skins on pebbles. A hand sample collected in 1999 and drilled cores collected in 2000 from the basalt flows all proved to be normally magnetized.

STRATIGRAPHIC INTERPRETATIONS

Pillow Point, Angel, and Tip section

Radiometric dating of flows at Tip, Angel, and Pillow Point sections has not yet been carried out. However, geomorphic evidence strongly suggests a Brunhes age. The termination of the flows at the level of the contemporary Yukon River floodplain and the presence of overlying gravel no more than 15 m above current river level suggests a middle to late Pleistocene age. In addition, airphoto interpretation suggests that these normally magnetized basalts filled a valley incising reversely magnetized lava flows erupted during the younger Matuyama Chron (Fig. 3; Jackson et al., 1996).

The foreset-bedded pillow breccia complexes found at Pillow Point section indicate flow of lava into a body of standing water. We postulate that this body of water was a lake likely created by the damming of the Yukon River during this eruption.

Holbrook Creek

It is uncertain to which eruptive event the flow found at Holbrook Creek belongs or if it was erupted during a separate event. Its reversed magnetization indicates that the flow's emplacement predates the Matuyama-Brunhes magnetic reversal (0.78 Ma). The pillowed base of the flow suggests that the flow was emplaced onto the Yukon River floodplain when the river was flowing at a higher level. Its stratigraphic and geomorphic setting suggests that it could be a far-reaching member of one of the Matuyama-aged eruptive events described by Jackson et al. (1996).

Rosebud Creek

It is uncertain whether the normal magnetization determined for the flow at Rosebud Creek indicates that the flow erupted during the Brunhes Chron (<0.78 Ma) or from one of the normal subchrons of the Matuyama. The gravel overlying the lava flow contains lithologies from the Selwyn Basin, which is hundreds of kilometres to the north and east, indicating that

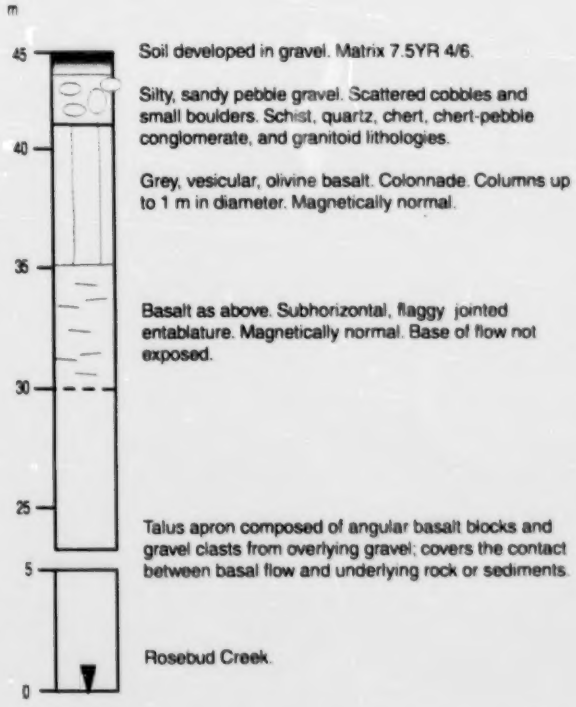
m
45
40
35
30
25
5
0
Soil developed in gravel. Matrix 7.5YR 4/6.
Silty, sandy pebble gravel. Scattered cobbles and small boulders. Schist, quartz, chert, chert-pebble conglomerate, and granitoid lithologies.
Grey, vesicular, olivine basalt. Colonnade. Columns up to 1 m in diameter. Magnetically normal.
Basalt as above. Subhorizontal, flaggy jointed entablature. Magnetically normal. Base of flow not exposed.
Talus apron composed of angular basalt blocks and gravel clasts from overlying gravel; covers the contact between basal flow and underlying rock or sediments.
Rosebud Creek.

Figure 6. *Strip log of sampled exposure of the basalt flow along the Rosebud Creek valley.*

it is glacial in origin. Only pre-Reid glaciations predating the Matuyama-Brunhes magnetic reversal were extensive enough to cross into the Rosebud Creek basin from the Yukon valley to the southeast or the Stewart River valley to the west (Jackson, 2000). The soil development in the gravels is consistent with a middle or early Pleistocene age. Furthermore, the geomorphic setting of the flow, including its almost complete erosional removal from the Rosebud Creek valley, and the elevation of its base above the contemporary floor of Rosebud Creek, is compatible with the same age range.

CONCLUSIONS

The discovery of normally magnetized flows within the valleys of Yukon River and Rosebud Creek suggests that the Selkirk Volcanic Group was erupted during as many as six events rather than the three events which were previously recognized. Prior to this study, the flows found at the contemporary level of the Yukon River's floodplain (Tip, Pillow Point, and Angel sections) were assumed to be reversely magnetized. This inferred that the Yukon River was flowing at or near its contemporary level a minimum of 780 ka BP. A Brunhes age for these flows suggests a lesser degree of stability than has been inferred by previous work. The Rosebud lava flows have a unique geomorphic and stratigraphic setting. They are normally magnetized but were erupted when Rosebud Creek was flowing at a higher level than it does today. This suggests that they are significantly older than the magnetically normal lava flows in the Yukon valley. The lava flows at Tip, Holbrook Creek, and Rosebud Creek will be radiometrically dated in order to provide controls on the rate and timing of incision of the Yukon and Stewart River systems.

ACKNOWLEDGMENTS

The authors gratefully acknowledge assistance and useful discussions in the field with Pierre Friele, logistical support by Heinz Saur and Rick Charlebois. Mike Villeneuve provided Ar-Ar dating of samples collected by Craig J. Hart of the Fort Selkirk flows. This work was in part supported by Northern Science Training Program grant from the Department of Indian Affairs and Northern Development.

REFERENCES

Bostock, H.S.
1936: Carmacks district, Yukon; Geological Survey of Canada, Memoir 189, 58 p.
1942: Ogilvie, Yukon Territory; Geological Survey of Canada, Map 711A, scale 1:253 440.
1966: Notes on glaciation in central Yukon Territory; Geological Survey of Canada, Paper 65-56, 18 p.

Cande, S.C. and Kent, D.V.
1995: Revised calibration of the geomagnetic polarity timescale for the Late Cretaceous and Cenozoic; Journal of Geophysical Research, v. 100, n. B4, p. 9093–6096.

Dubois, P.M.
1959: Late Tertiary geomagnetic field in northwestern Canada; Nature (London), v. 183, p. 1617–1618.

Duk-Rodkin, A.
1999: Glacial limits of Yukon; Geological Survey of Canada, Open File 3694, scale 1:1 000 000.

Francis, D. and Ludden, J.
1990: The mantle source for olivine nephelinite, basanite and alkaline olivine basalt at Fort Selkirk, Yukon, Canada; Journal of Petrology, v. 31, p. 371–400.

Hughes, O.L., Campbell, R.B., Muller, J.E., and Wheeler, J.O.
1969: Glacial limits and flow patterns, Yukon Territory, south of 65° north latitude; Geological Survey of Canada, Paper 68-34 , 9 p.

Jackson, L.E., Jr.
2000: Quaternary geology of the Carmacks map area, Yukon Territory; Geological Survey of Canada, Bulletin 539, 74 p.

Jackson, L.E., Jr., Barendregt, R., Baker, J., and Irving, E.
1996: Early Pleistocene volcanism and glaciation in central Yukon: new chronology from field studies and paleomagnetism; Canadian Journal of Earth Sciences, v. 33, p. 904–916.

Jackson, L.E., Jr., Barendregt, R., Irving, E., and Ward. B.
1990: Magnetostratigraphy of early to middle Pleistocene basalts and sediments, Fort Selkirk area, Yukon Territory; *in* Current Research, Part E; Geological Survey of Canada, Paper 90-1E, p. 277–286.

Naeser, N.D., Westgate, J.A., Hughes, O.L., and Pewe, T.L.
1982: Fission-track ages of late Cenozoic distal tephra beds in the Yukon Territory and Alaska; Canadian Journal of Earth Sciences, v. 19, p. 2167–2178.

Walton, A., Troutman, M.A., and Friend, J.P.
1961: Isotopes Inc. radiocarbon measurements part 1; Radiocarbon, v. 3, p. 47–59.

Westgate, J.A.
1989: Isothermal plateau fission-track ages of hydrated glass shards from silicic tephra beds; Earth and Planetary Science Letters, v. 95, p. 226–234.

Geological Survey of Canada Project 990002-07